# A WATERSHED APPROACH FOR SUSTAINABLE ECOSYSTEM MANAGEMENT OF MEENACHIL RIVER BASIN WITH EMPHASIS ON REMOTE SENSING AND GIS

Synopsis

**Introduction:** The twentieth century has witnessed unprecedented rise in human population, from 2.8 billion in 1955 to 5.3 billion in 1990 and is expected to reach between 7.9 and 9.1 billion by 2025 (Engleman and LeRoy, 1993). Consequently, human demands for water, for domestic, industrial and agricultural purposes, are also increasing rapidly (Gleick, 1993). The present study is a watershed-based approach to ecosystem management of the Meenachil river basin. It recognizes the connections between the elements of the ecosystem located within a watershed. Watersheds cross political boundaries, thus watershed-based planning is considered a more comprehensive and integrated way of managing the environment than local or regional planning, which function within municipal boundaries.

**Study area:** Meenachil River originates from Araikunnumudi at an elevation of 1097 m above mean sea level (MSL). Its watershed extend from 9º25' to 9º55' N and 76º20' to 76º55' E. The major river draining has a length of 78 km with an area of 1272 $km^2$. This river may be the only one in Kerala, which is characterized by the presence of human settlement right from the source of the river to its confluence with the Vembanad Lake, adversely affecting the river and river basin.

**The objectives of this study are**

1. To study the morphometry of selected subwatersheds of Meenachil river.
2. To study the landuse pattern of the subsystems of Meenachil river.
3. To assess the water quality parameters of the different watersheds of the Meenachil river.
4. To evaluate the hydrochemical characteristics and spatial evaluation of ground water quality of different watersheds of the Meenachil River Basin
5. To delineate the groundwater prospect zones of the selected subwatersheds of Meenachil river.
6. To study the selected aspects of biodiversity with reference to the flora & fauna of the different subsystems of Meenachil river.
7. To suggest and recommend methods for conservation strategies for sustainable ecosystem management

**Methodology:** Integration of remote sensing data and the geographical information system (GIS) for the exploration of groundwater resources has created a breakthrough in the field of groundwater research, which assists in assessing, monitoring and conserving groundwater resources. In this study, various groundwater potential zones for the assessment of groundwater availability in five subwatersheds of Meenachil river basin have been delineated using remote sensing and GIS techniques. Survey of India toposheets and IRS-1C satellite imageries are used to prepare various thematic layers viz. lithology, geomorphology, landuse, lineament density, drainage density and slope. The raster maps of these factors

are allocated a fixed score and weighted overlay analysis was done. The groundwater potential zones thus obtained were divided into five categories, viz., not suitable, less suitable, moderately suitable, suitable and highly suitable.

The quantitative analysis of linear, relief and areal morphometric parameters using GIS is found to be of immense utility in river basin evaluation, watershed prioritization for soil and water conservation and natural resource management at the micro level. The drainage morphometry of a river basin reflects the hydrogeologic maturity of that river. The analysis helps to establish various relationships between the drainage basin and the hydrogeologic parameters. The drainage network of the subwatersheds was delineated using SOI topographical maps on 1:50,000 scale using ArcGIS. The stream orders were calculated using the method proposed by Strahler (1964). The seasonal water quality parameters of the study area in different locations were analyzed based on APHA 1998 procedures. The landuse/land cover pattern of different subsystems of Meenachil River was also studied.

**Results and discussion:** The drainage network reveals that the terrain exhibits dendritic to sub-dendritic drainage pattern. Stream order ranges from the fifth to the sixth order. Land is becoming a scarce commodity the world over due to immense agricultural and demographic pressure. Hence, information on landuse/land cover change (LULCC) and possibilities for their optimal use are essential for the selection, planning, implementation and monitoring of development schemes to meet the increasing demands for basic human needs and welfare while at the same time preserving biodiversity, especially in developing countries. Downstream, water environment conditions are more unfavourable because of domestic and industrial effluents coming from the urban areas through the main stream. Indeed, the values obtained for dissolved oxygen, decrease from up to downstream of the river, and are related to the bacterial metabolism that uses this element to damage the abundant organic matter in this sector. The presence of fecal coliforms and streptococci points to the domestic discharges of the townships. This phenomenon is probably accentuated by intense precipitation that leaches out ions from the watershed. The detection and isolation of *E. coli* and *V. parahaemolyticus*, *V. cholerae* and *Salmonella enterica* from Meenachil river basin indicates the frequent discharge of sewage containing pathogenic microorganisms into the riverine ecosystem and also the extended survival of these organisms to a detectable level at higher concentrations. The survival and persistence of these bacteria in natural environments is of utmost importance to public health as the population in this region uses this water body for several domestic purposes. This water body supports major fish and shellfish resources and the presence of these pathogenic bacteria poses a public health hazard through related food borne epidemics. The investigation on the microbial ecology in the runoff of the river in relation to pollution has revealed the obvious and significant presence of bacterial indicators of faecal pollution in the middle and lower stretches of the river. The water quality and hence the health of the Meenachil river basin is alarming.

Systematic sampling of 41 groundwater samples was carried out during 2009-2013 to evaluate the major ion chemistry, the factors controlling water composition, and suitability of groundwater for both drinking and irrigation purposes. All the parameters analyzed are below the desirable limits of WHO and Indian standards for drinking water. Hence, considering the pH, the groundwater in the study area is not suitable for drinking but can be used for irrigation, industrial and domestic purposes. In order to determine the geochemical nature of water, the data was interpreted using the Piper diagram wherein the results show the predominance of the Ca-Mg-$HCO_3$-Cl type in the pre-monsoon and a dominance of Ca-Na-Mg-$HCO_3$-Cl type in the post-monsoon period, followed by Na-Ca-$HCO_3$-Cl and Ca-Na-$HCO_3$-Cl type water. The alkaline earth (Ca + Mg) exceeds alkalis (Na + K); and weak acids ($CO_3$ + $HCO_3$) exceed strong acids ($SO_4$ + Cl) in all samples of the pre-monsoon season. The percentage sodium and electrical conductance correlated by Wilcox showed that all the samples fall in the field of excellent to good. The SAR values of all the samples are found within the range of excellent category. United States salinity diagram (Wilcox 1948) obtained by plotting the correlation between SAR and electrical conductivity indicated low to high salinity and low to medium alkalinity water, which can be used for irrigation.

The present work also aimed at evaluating the riparian species diversity of five subwatersheds of the Meenachil river basin (1208.1 $km^2$) and to compare that with the main river channel. A total of 441 species were recorded belonging to 106 families. The Leguminosae was represented by the highest number of species (39 spp.) followed by Poaceae (25 spp.). Butterflies are highly sensitive to environmental change and are delicate creatures that act as good bio-indicators of the health of an ecosystem. A survey of the butterflies conducted randomly revealed a total of 91 species belonging to five families including three endemic species. Family Nymphalidae dominated in the study area, followed by Hesperiidae and Lycaenidae. This area is currently under severe anthropogenic pressure and minimizing these disturbances is important for the long-term survival of specialist butterflies. 51 species of fishes and 97 species of birds were also reported from the study area.

Sand mining, a severe environmental problem to the river basins have numerous impacts on land, water and biota. Instream sand mining in the Meenachil River has altered the channel geometry and bed elevation as well as reduced the riverine stockpiling of sediment and has adversely affected the quality of water. Reduction in the distribution and abundance of some species of plants, birds and fishes was also observed. Although the riverine vegetation is regarded as biologically rich and is currently threatened, no detailed floristic information is available.

The findings of this study thus provides valuable information to water resource managers, environmentalists and investigators for the implementation of appropriate strategies for the improvement of water quality management efforts. Further research is recommended to monitor other water quality parameters for the existence of trends in them.